PATENT SPECIFICATION

Application Date: Dec. 22, 1937. No. 35432/37. 508,372

Complete Specification Left: Dec. 22, 1938.

Complete Specification Accepted: June 22, 1939.

PROVISIONAL SPECIFICATION

Improvements in or relating to Adsorption Apparatus

I, ARTHUR LEONARD SADLER, a British Subject, of Ocean Chambers, 44, Waterloo Street, Birmingham 2, do hereby declare the nature of this invention (a Communication to me by Pittsburgh Lectrodryer Corporation, a Corporation duly organized under the Laws of the State of Pennsylvania, United States of America, of 32nd Street and Allegheny River, Pittsburgh, Pennsylvania, United States of America) to be as follows:—

This invention has reference to adsorption apparatus of the type adopted to recondition air, gas or other fluid and is particularly, although not exclusively, adapted for drying or de-humidifying or purifying air or gases, for use in providing special atmospheres in rooms or building interiors or in annealing or other heat-treatment furnaces or the like.

Heretofore adsorption apparatus for such purposes has comprised several containers for adsorption substance and whilst one of the said containers is being used for drying or purifying purposes the other or others is or are being re-activated or de-humidified by heated air, or cooled, so that only one of the containers is utilized at any given time and also provision has to be made to changeover the containers manually at certain definite times.

The principal objects of the present invention are to overcome these disadvantages, and at the same time provide adsorption apparatus which comprises a single container wherein the successive processes of moisture-adsorption or purification of a fluid and of reactivation and cooling of the adsorption substance are carried on continuously and automatically; which is capable of drying or purifying large volumes of gas or fluid per unit of time and which is of simple and compact construction whilst being inexpensive to construct and maintain and efficient and certain in operation.

In accordance with the present invention, an adsorption apparatus comprises a plurality of chambers in which adsorption substance is located, and a valve adapted to distribute three separate streams of air gas or other fluid (one of which is to be dried or purified whilst another reactivates the adsorption substance and the third cools the said substance) to the several chambers in a predetermined sequence, the container and valve being rotatable or displaceable relatively to one another.

In a typical application of the said invention, an adsorption apparatus for drying air or gases for supply to the interior of a room or building or for use as the treatment chamber atmosphere of an annealing or similar furnace, comprises a substantially cylindrical casing having a central axial housing or passage wherein a rotatable valve unit is accommodated. This annular casing may be lined with heat insulating material and may be divided, preferably by insulated radial walls or partitions, into eight chambers of equal dimensions, in each of which one or more trays is or are so located that a space is formed at each end of the several chambers. Each of the trays is filled with an adsorbent substance, for example, activated alumina, and is perforated or made from gauze-like material so that gases may be passed through the said substance; also the said chambers are so partitioned or divided that the gases are compelled to pass through a tray or trays when flowing from end to end thereof, and when two or more trays are superimposed in one chamber, the arrangement may be such that the contents of each tray treats, or is treated by, a certain proportion of the gases that are flowing through the said chamber at any given time.

The wall of the valve housing is preferably so ported or apertured that a port is provided at or towards either end of each of the casing chambers so that gas may flow from the housing into one end of each chamber, through adsorption substance in one or more trays and out of the other end of the said chamber back into the housing. The valve unit, which is preferably in the form of a hollow drum, is a close fit within the said housing and may be provided with a corresponding number and disposition of ports which register simultaneously with the chamber ports.

Preferably the said valve unit is located vertically within, and extends above and

below, the casing, and is divided by a central transverse partition into two halves. The lower half of the valve may itself be divided by a longitudinal partition into two separate and substantially equal compartments, each of which may be formed with four ports which register simultaneously with ports in the corresponding ends of four of the casing chambers. One of these lower valve compartments may open into a cap or cover that sockets over the bottom end of the valve and is fixed to the underside of the casing, whereas the other lower compartment is formed with an additional port or system of ports that put it into communication with an annular conduit disposed around the bottom cap or cover.

The upper half of the valve is divided into three unequal compartments by longitudinal partitions, one of which is of such dimensions and is so ported that it communicates simultaneously with four casing chambers, whilst another can communicate with three of the said chambers and the third can communicate with only one chamber. The largest and smallest of these three upper chambers may also open into an external cap or cover which is fixed to the top of the casing and sockets over the upper protruding end of the valve, whereas the third of the said chambers is provided with an additional radial port or system of ports which open into an annular conduit disposed around the top or cover. The annular conduit and cap located on the top of the casing communicates respectively with an intake and exhaust fan or blower, whereas the bottom cap or cover, which may be open to the atmosphere, contains an electric, gas, steam, or other heater, and the surrounding conduit communicates with the interior of the furnace treatment chamber to which the dry or purified gas, or air, is to be supplied, or with a storage tank or reservoir. Preferably, all the partitions within the valve are lined with asbestos or other heat insulating material.

The apparatus also comprises an electric motor or other source of power which may be so coupled through reduction gearing to the rotatable valve that it is adapted, when the casing is divided into eight equal chambers, to turn the valve suddenly and at predetermined intervals of time, through an angle of approximately 45°. For example, the top of the valve may be provided with a pin or spindle whereon a spider having eight equally spaced arms is keyed or otherwise secured and the motor may be arranged to rotate a vertical shaft which carries a horizontal lever that is adapted to strike and displace one of the spider arms once for each revolution of the shaft.

When the apparatus is in operation, the following three fluid or gas streams are caused to flow simultaneously through the casing and valve:—

(a) The air or gas to be dried or purified is forced into the top cap or cover by the intake blower and the majority of this air or gas passes into the largest of the three upper valve compartments, through the four radial ports in the said compartment and the ports in the top of the four casing chambers in register therewith, into the top of the chambers. The fluid then passes downwardly through the adsorbent substance, when it is dried or purified, into the bottom of the said chambers, through the lower parts of the latter, and the four registering ports in the lower closed compartment of the valve, into the interior of the valve, from which it passes through an additional port or ports in the said lower closed compartment and the annular conduit on the underside of the casing, into a pipe leading to the interior of a room or building or of a furnace treatment chamber or storage tank. Preferably, a length of this pipe may be surrounded by a water jacket or similar means for cooling the dried or purified gas.

(b) Atmospheric air is drawn by the suction fan or blower connected to the annular conduit on the top of the casing, through the cap or cover on the underside of the latter, where it is heated to a predetermined temperature, into the interior of the open-ended lower valve compartment. This heated air passes through three of the four ports in the said compartment and the registering ports in the three complementary casing chambers into the bottom end of the latter, upwards through the adsorption substance in the trays housed therein to dry or reactivate the said substance and through the corresponding registering ports in the valve and valve housing into the closed upper and second largest valve compartment from which it passes into the annular conduit through the additional radial port or system of ports provided in the said compartment, and so to the blower.

(c) The remainder of the undried or unpurified air forced into the upper cap or cover passes into the open-ended smallest compartment in the upper end of the valve, through the single radial port provided therein and the registering upper port of the eighth casing chamber, into the top of the latter. This gas then flows downwards, through the adsorbent substance in the tray or trays, into the bottom of the said chamber and passes through the bottom port of the latter and the fourth registering port of the open-ended com-

partment in the lower half of the valve, where it mixes with the stream of hot air rising through the cap or cover on the underside of the casing. It is essential that this cooling air should flow through the casing in the same direction as the air or gas under treatment.

As the air or gas that is to be dried or purified passes through the adsorbent substance it gradually destroys the drying and/or purifying properties of the said substance and the time taken for this substance to reach saturation point when it no longer performs its drying or purifying effect in an efficient manner, is the main consideration which determines the interval between the intermittent angular movements imparted to the valve. Further the passage of the hot air through the adsorbent substance restores its drying and/or purifying properties but at the same time raises its temperature to an undesirable or unpermissible value. Therefore, it is necessary to cool the substance before it again commences its drying or purifying operation, and this cooling is effected by the small proportion of untreated gas that is forced through the smallest of the three compartments in the upper half of the valve.

It will be appreciated that the valve is rotated in such a direction, and the several valve compartments are so located that after the efficiency of the adsorbent material has been reduced to a predetermined minimum by the untreated air or gas, it is first subjected to the drying or reactivating effect of the hot air and is then cooled. Also, since each angular movement of the valve is only sufficient to take the valve ports into register with the ports of the next adjacent chamber of the casing, the interval between each such movement must be equal to one-quarter of the time taken for the adsorbent substance to reach its predetermined minimum degree of efficiency, and that the volumes of the reactivating and cooling medium flowing through the cooling must be so regulated or controlled that the said substance is restored to its original condition before it is again put into use.

Obviously, if desired, the valve may be a fixture and the chambered casing may be rotated by the electric or other motor; also the said motor may be arranged to drive the two blowers, in addition to the valve or casing, or an additional motor or motors may be provided for this purpose.

Also, if desired, the heater in the cap or cover on the underside of the casing may be eliminated and hot air may be taken from some suitable external source, whilst the casing may be divided into any other convenient number of adsorption chambers, although it is advisable that the number of radial ports in the valve which register with the chamber ports, should always be double the number of the said chambers.

Dated this 21st day of December, 1937.

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COMPLETE SPECIFICATION

Improvements in or relating to Adsorption Apparatus

I, ARTHUR LEONARD SADLER, a British Subject, of Ocean Chambers, 44, Waterloo Street, Birmingham 2, do hereby declare the nature of this invention (a Communication to me by Pittsburgh Lectrodryer Corporation, a Corporation duly organized under the Laws of the State of Pennsylvania, United States of America, of 32nd Street and Allegheny River, Pittsburgh, Pennsylvania, United States of America) and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention comprises improvements in or relating to the treatment of gaseous fluids in adsorption apparatus, and is particularly concerned with the drying or de-humidifying, or purifying of air or gases in which treatment of fluid by adsorption material, and reactivation of the latter, proceed concurrently and in sequence in different zones of the bed of material. Such treated air or gases may be employed in rooms, or building interiors, or in annealing or other heat treatment furnaces, and so on.

The principal object of the present invention is to provide an improved construction of valve for supplying and delivering separate streams of fluid to appropriate sectors or zones of the bed of the material in predetermined sequence for the continuous treatment of large volumes of air or gas, and so as to give an uninterrupted flow of treated air or gas.

According to the present invention, adsorption apparatus for the treatment of gaseous fluids comprises a bed or beds of adsorptive materials subdivided into sectors or zones, chambers disposed above

and below said bed or beds, and a rotary cylindrical circumferentially ported valve extending through said bed or beds and adapted for supplying and delivering separate streams of treatment and reactivation fluid to such chambers for their passage through the different sectors or zones in predetermined sequence and from the upper to the lower chambers and *vice versa*, so that the streams pass through the bed or beds in opposite directions.

The valve is also preferably adapted for supplying and delivering a stream of cooling or purging fluid to and from a reactivated zone of the adsorption material, preferably activated alumina, before it is employed for treatment of the fluid. Thus the valve provides for the flow of the respective fluid streams in the predetermined sequence through each zone or sector. Thus air to be treated is denuded of moisture in a zone of adsorptive material which, as it approaches saturation, is reactivated by the removal of moisture, the material then being cooled, and purged of undesirable impurities. The valve is in the form of a rotary sleeve extending centrally through the sector-like zones of adsorptive material disposed in the form of a flat bed between the chambers which are sub-divided into sector-like parts for the supply and delivery of the respective streams. The valve may be formed with a horizontal web for dividing it into upper and lower portions each communicating with respective chambers, these portions being divided by radial partitions into ducts for the different fluid streams. Thus the valve, rotatable in a ported sleeve, may be formed with a vertical central partition to provide ducts for the supply and delivery of treatment and reactivating streams to and from the chambers after passing through the adsorptive material, one portion of the valve also being provided with an additional vertical partition to form a duct for the purging or cooling stream. The arrangement is such that the treatment fluid passes through the bed in the opposite direction to that of the reactivating fluid, while the purging or cooling fluid passes through the bed in the same direction as the treatment fluid for the purpose hereinafter described. The purging air is conveniently taken from the supply of treatment fluid and after passing through the bed it may flow and mingle with the reactivating fluid.

In order to enable the invention to be readily understood reference will now be made to the accompanying drawings illustrating by way of example different constructions for carrying the invention into effect, in which drawing

Figures 1 and 2 are perspective views of one arrangement with parts removed to disclose the interior construction.

Figure 3 is a sectional elevation showing the valve and sleeve of Figures 1 and 2.

Figures 4, 5, 6, and 7 are sections on the lines A—A, B—B, C—C, and D—D, of Figure 3.

Figure 8 is a sectional elevation on the line E—E, Figure 9, illustrating part of a modified construction in which a separate purging air flow is provided.

Figure 9 is a plan of Figure 8.

Figure 10 is a central vertical section of a modified construction.

Figures 11 and 12 are horizontal sectional views on the line F—F, and G—G, Figure 10.

Figure 13 is a vertical sectional view on the line H—H, Figure 10.

Figures 14 and 15 are horizontal sectional views through the valve and casing on the lines I—I and J—J respectively, Figure 10.

Figure 16 is a side elevation of the valve, Figure 10, removed from its casing.

Referring to Figures 1 to 7, a cylindrical casing *a* is provided with two or more layers or beds *b* of adsorptive material, such as activated alumina, and is subdivided into a number of sector-like zones *c* by radial partitions *d*. A ported cylindrical valve *f* rotatable within a ported sleeve *g* extends centrally through the container and is adapted to control the flow of three streams of fluid through the beds of activated material. One of these streams is the treatment fluid, moist air for example, another is the reactivating fluid, which may be warm air, and the third is the purging or cooling fluid which may consist of a portion of the treatment fluid. The fluid streams are passed successively through different zones of the beds, while the treatment, reactivating, and purging operations proceed concurrently in the different zones. The moist air for treatment is drawn in through an upper inlet h^1 by a fan *h* disposed on the cover of the container and passes into the cylindrical valve, ports and partitions in which restrict the delivery of air into certain only of the sector-like chambers *c*. Thus the moist air passes only through the corresponding zones of the adsorptive material. After being dried by the latter the air flows out of the lower end of the valve and after being cooled by passing over cooling coils *i*, for example, it is discharged through an outlet *j*. The reactivating air is admitted to the lower end of the cylindrical valve through an inlet *k* and after being warmed by any suitable

means *l*, such as heating coils or a gas burner, it is admitted through ports in the valve to certain of the sector-like chambers and the corresponding zones of the adsorptive material. The third stream of fluid is bypassed from the supply of treatment fluid and is admitted by appropriate ports in the valve to certain of the sector-like chambers. It then flows through the corresponding zones of the material and finally mixes with the reactivating air, which is discharged through the outlet *m* by the blower or fan *n*.

The valve is rotated in such manner that the three streams pass successively through different zones of the adsorptive material. Thus as a zone of the latter becomes saturated due to the drying of treatment fluid, the rotation of the valve brings such zone into communication with the reactivating fluid which removes the moisture and reactivates the absorbent material. The further rotation of the valve causes the zone to be connected up in the purging circuit with the result that the material is cooled and any impurities are removed by this fluid. Different zones of the beds are subjected concurrently to each of the three operations, the rotary valve enabling successive operations to be performed in each zone, automatically without the necessity for manual change-over.

The blowers *h n* are mounted on the upper part of the container *a* which has an upper chamber *e* communicating with the reactivating blower, a chamber *p* at the lower part of the container communicating with the outlet for the dried air. The valve *f* is rotatable in a ported sleeve *g* having a circumferential flange or flanges *r* which separates the layers *b* at their inner peripheries.

The rotary cylindrical valve is provided with a vertical central web or partition *s* dividing the valve body vertically into halves. A horizontal partition *t* completely blocks the interior of the valve body at the central portion thereof, at a level coinciding with the centre of the adsorbent beds. The bottom of the valve is partly closed by a semi-circular horizontal web *u* extending from the vertical partition *s* to the side walls of the valve. A vertical radial partition *v* in the upper half of the valve extends from the partition *s* to the wall of the valve, and when the chambers are divided into eight sectors, the radial partition will extend at an angle of 45° from the partition to form a purging duct *w* in the upper half of the valve. The upper half of the valve is thus divided into three ducts, namely, an absorbent duct *x* extending through an arc of 180°, a reactivating duct *y* extending through an arc of 135° and the purging duct *w* extending through an arc of 45°. The purging and adsorption ducts *w x* are open at the top while the reactivating duct *y* is closed by a horizontal web *z*. The lower part of the valve is divided into an absorbent duct x^1 and a reactivating duct y^1 each of semi-circular shape in section, the absorbent duct being closed by the web *u* at its lower end, whilst the reactivating duct y^1 is open and communicates with a conduit leading to the inlet *k*.

Treatment fluid passes from the supply passage h^1 into the upper end of the duct *x*, and flows outwardly through a port X in the valve *f* and four of the ports T^1 in the sleeve *g*, through the beds of material *b*, thence through port X^1 in the valve and four of the ports T^2 in the sleeve into the duct x^1, from which the dry air passes into the chamber *p* through ports T^3 and is discharged through the outlet *j*. Reactivating air passes from the inlet *k* into the valve duct y^1, thence flows through valve port Y^1 and four of the opposite ports T^2 in the sleeve (Figure 6), passes through the beds *b*, re-enters the duct *y* in the upper part of the valve through three sleeve ports T^1 opposite valve port Y^2 and is discharged through ports R^3 in communication with the chamber *e* and passes to the outlet *m*. A part of the treatment fluid is by-passed from the supply pipe h^1 and passes into the duct *w* from which it flows through a sleeve port T^1 and a valve port W, through the beds *b* and then mixes with the reactivating stream in the duct y^1 in the lower part of the valve. The three fluid streams are represented by flow lines, as follows:— The treatment fluid is shown in full lines, the reactivating fluid by dotted lines, and the purging fluid by chain-dot lines.

It will be appreciated that the valve is rotated in such a direction, and the several valve compartments are so located that after the efficiency of the absorbent material has been reduced to a predetermined minimum by the untreated air or gas, it is first subjected to the drying or reactivating effect of the hot air and is then cooled. Also, since each angular movement of the valve is only sufficient to take the valve ports into register with the ports of the next adjacent chamber of the casing, the interval between each such movement must be equal to one-quarter of the time taken for the absorbent substance to reach its predetermined minimum degree of efficiency, and that the volumes of the reactivating and cooling medium flowing through the casing must be so regulated or controlled that the said

substance is restored to its original condition before it is again put into use.

Also, if desired, the heater in the cap or cover on the underside of the casing may be eliminated and hot air may be taken from some suitable external source, whilst the casing may be divided into any other convenient number of absorption chambers, although it is advisable that the number of radial ports in the valve which register with the chamber ports, should always be double the number of the said chambers.

According to the modified arrangement shown in Figures 8 and 9, the purging or cooling air is supplied separately instead of being bye-passed from the treatment air as in Figure 1 to Figure 7. The purging air introduced by the motor driven blower 2 passes through a duct 3 into the valve sector 4 and into the container for the alumina by way of the ports in the rotary valve *f* and the stationary valve sleeve *g*. The moist air drawn in by a blower 3^1 passes into the valve sector 4^1 and thence through ports to the adsorptive material, while the reactivating exhauster 5 driven by the same motor 6 as drives the blower 3^1 draws air through from the valve sector 4^2.

According to the modified construction shown in Figures 10 to 16, the fans 7 7^1 and valve driving gear 8 are disposed below the bed 9 of absorptive material. The cylindrical valve 10 is rotated by the motor 11 and extends through a sleeve 12 disposed centrally in the container. The absorbing unit, Figure 10, which may be introduced through an open top of the container may be removably mounted on brackets 13 on the container. The absorbing unit comprises upper and lower plates 14 lined with insulating material 15, spaced apart by side plates 16 and secured by bolts or tie rods. The space between the container walls and the side plates is filled with heat insulating material 18 which may be removable with the unit or secured to the casing.

The layer of adsorbent material 9 extending from the side plates to the valve sleeve 12 divides the space within the unit. Fine mesh wire screens 19 cover the top and bottom of the absorbent layer and a heavy screen 20 of larger mesh is arranged above and below the layer of absorbent and welded to the side plate 16 and the valve sleeve 12 to secure the layer in position. Vertical metal partitions 21 divide the adsorber unit and adsorbent bed into a number of sectors, of equal area. An exhaust chamber 26^b is formed by an inverted cover 27 secured to the outer edges of the lower plate 14 and surrounding the lower end of the valve sleeve 12 which terminates immediately below the said cover.

A cover 28 is removably secured by clips 29 to the upper part of the casing and forms an air tight joint. A conduit 30 extends centrally through the cover and seats around the valve sleeve 12 a heater 31 of any suitable type, such as an electrical resistance heater, a gas, steam or oil heater being disposed in the casing. A suitable air cooler 35 is supported in the cover adjacent the outlet 36 for dry air.

In operation the motor 11 drives the fans 7 7^1 and the valve motor 8 rotates the valve 10 at a slow speed. Fluid to be treated is drawn in through inlet 32 and forced by the intake fan 7 into the chamber 26, from which it passes into the lower open end of a valve duct 33, thence through a valve port 57 and casing ports 48, and adsorbent beds 9, and out through casing ports 47 and valve port 55 into chamber 26^a. The heat of adsorption is removed by a cooler 35 as the dried air passes out through the outlet 36. The exhaust fan 7^1 draws air down through the conduit 30 where it is heated by a heater 31 into the upper reactivating valve duct, through valve port 37, casing ports 47, the adsorbent beds, casing ports 48 and valve port 59 into chamber 26^b from which it passes through a conduit 42 to an outlet 43 which discharges the reactivating air. Purging air enters the lower end of the purging valve duct from the chamber 26 and passes through valve port 58 and one of the casing ports 48 through a bed of adsorbent material, thence through one of the casing ports 47 into the upper reactivating duct of the valve, where it reverses its flows and mixes with its reactivating air admitted through the conduit 30.

The operation is similar to that already described with reference to Figures 1 to 6, the valve, shown in detail in Figure 16 with flow lines for the different fluid streams, being of similar construction.

The valve may be built up instead of a one-piece construction as shown. The driving apparatus for the valve may be adapted to turn the valve intermittently through an appropriate angular distance. For small sizes, however, the valve may be continuously rotated through a direct coupling.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. Adsorption apparatus for the treatment of gaseous fluids comprising a bed or beds of adsorptive materials subdivided into sectors or zones, chambers disposed

above and below said bed or beds, and a rotary cylindrical circumferentially ported valve extending through said bed or beds and adapted for supplying and delivering separate streams of treatment and reactivation fluid to such chambers for their passage through the different sectors or zones in predetermined sequence and from the upper to the lower chambers and *vice-versa*, so that the streams pass through the bed or beds in opposite directions.

2. Adsorption apparatus for the treatment of gaseous fluids in accordance with Claim 1, in which the valve is provided with a duct and ports adapted for supplying cooling or purging fluid to the adsorption material after reactivation of the latter.

3. Adsorption apparatus for the treatment of gaseous fluids in accordance with Claim 1 or Claim 2, comprising a valve, rotatable within a ported sleeve, and formed with a horizontal web for dividing it into upper and lower positions, each communicating with a chamber, and with a vertical central partition providing ducts in each portion for the respective fluid streams.

4. In adsorption apparatus for the treatment of gaseous fluids in accordance with Claim 3, the provision of an additional vertical partition forming a duct for the passage of a stream of cooling or purging fluid to the adsorption material after it has been subjected to reactivation.

5. In apparatus for the treatment of gaseous fluid in accordance with any one of the preceding claims, the provision of beds of adsorptive material, such as activated alumina, disposed between chambers partitioned for delivering the fluid streams to different beds.

6. In apparatus for the treatment of gaseous fluid in accordance with Claim 2, the provision in the upper or lower part of the valve of ducts for treatment, reactivating, and cooling or purging fluid, and in the other part of two ducts for treatment and reactivating fluid substantially as described.

7. In adsorption apparatus for the treatment of gaseous fluids in accordance with any one of the preceding Claims, the provision of means for separately supplying purging or cooling air to the valve.

8. Adsorption apparatus for the treatment of gaseous fluids in accordance with Claim 2, in which the treatment fluid passes through the bed in the opposite direction to that of the reactivating fluid, while the purging or cooling fluid passes through the bed in the same direction as the treatment fluid.

9. Adsorption apparatus for the treatment of gaseous fluids in accordance with Claim 2, in which the purging or cooling air is taken from the supply of treatment fluid and after passing through the bed mixes with the reactivating fluid.

10. Adsorption apparatus for the treatment of gaseous fluid constructed and adapted for operation, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 19th day of December, 1938.

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Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

Fig. 1

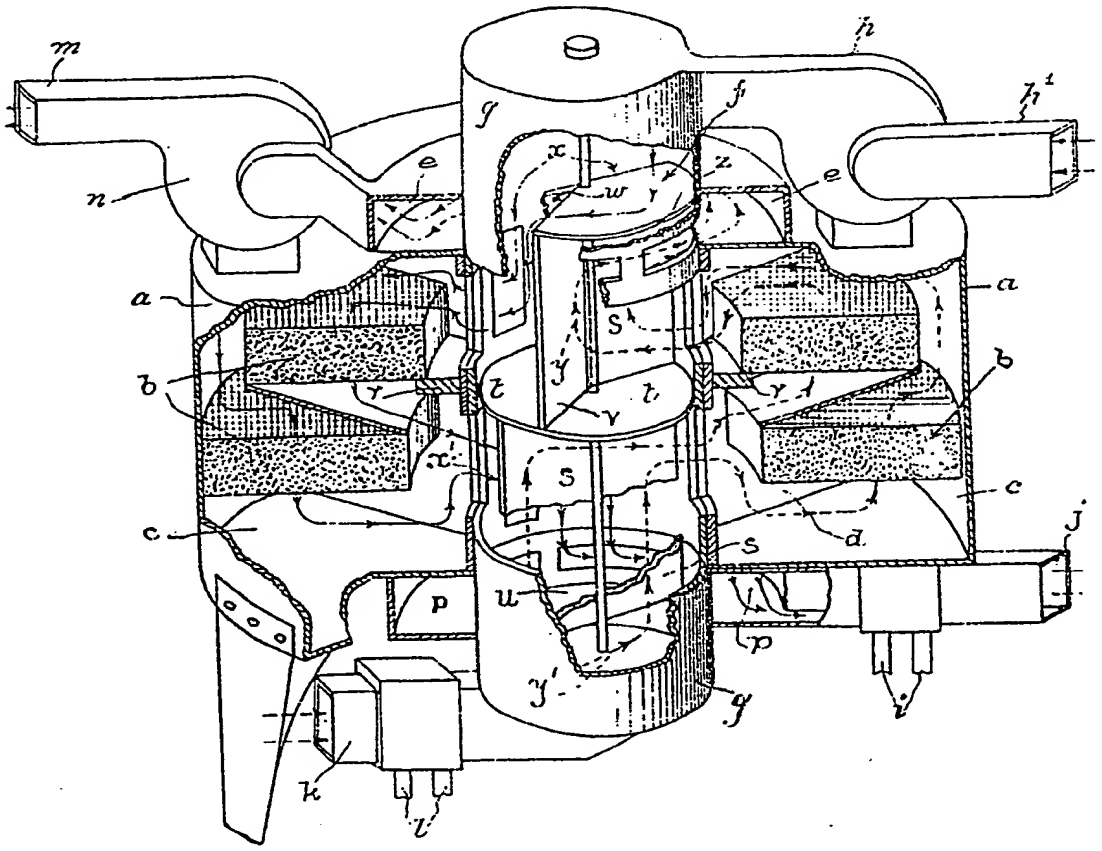
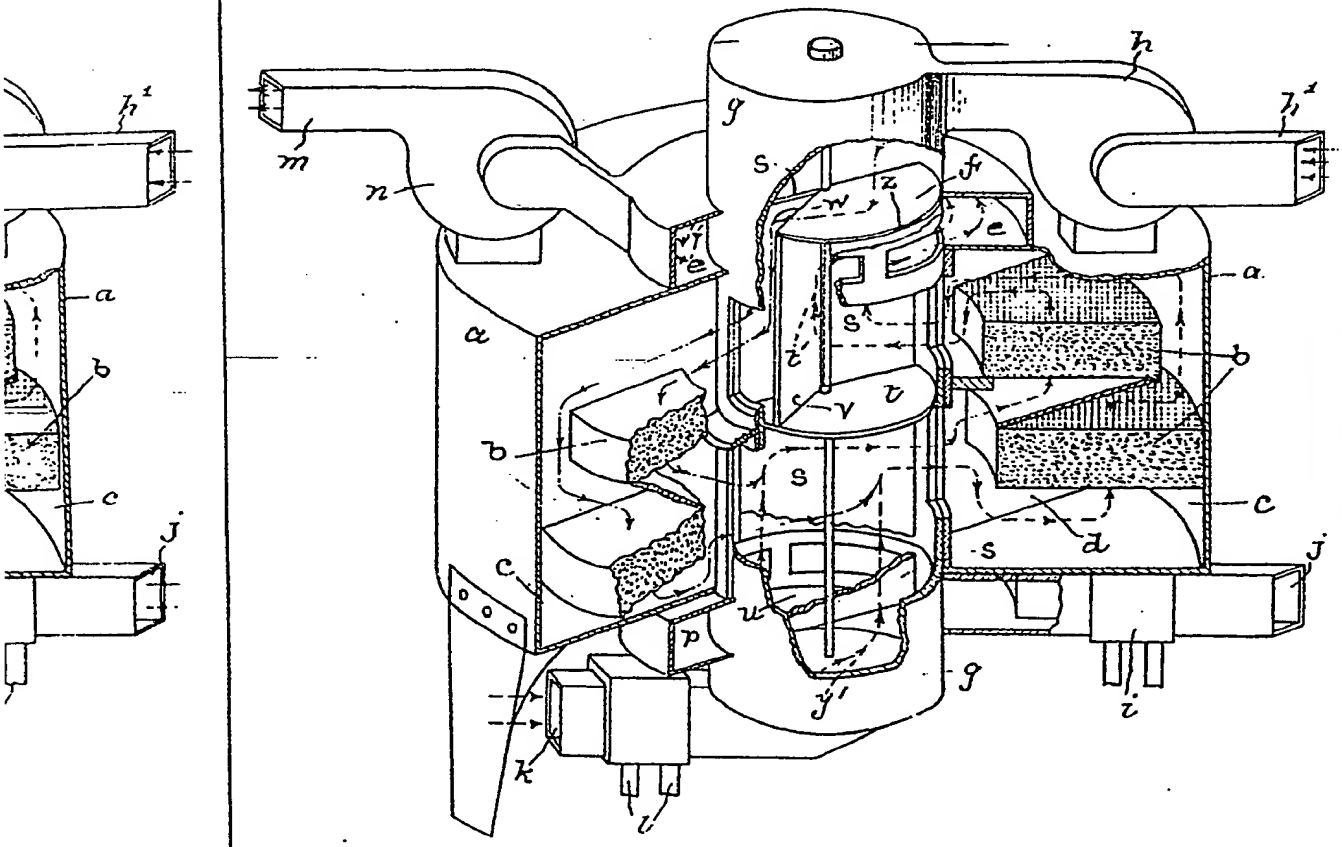


Fig. 2



Malby & Sons, Photo-Litho.

Fig. 1

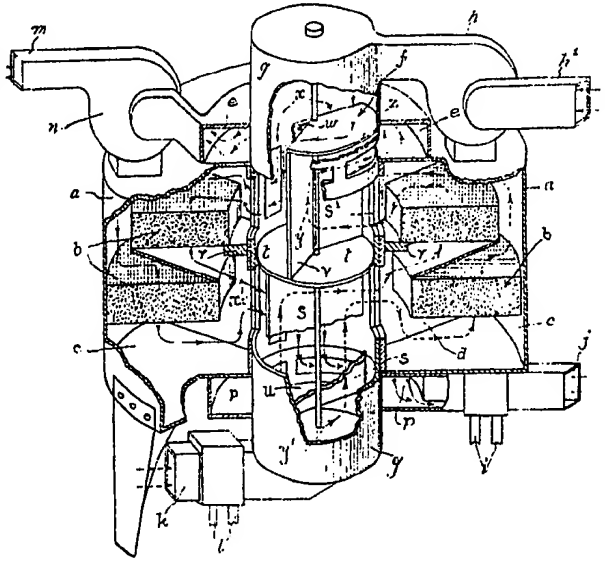


Fig. 2

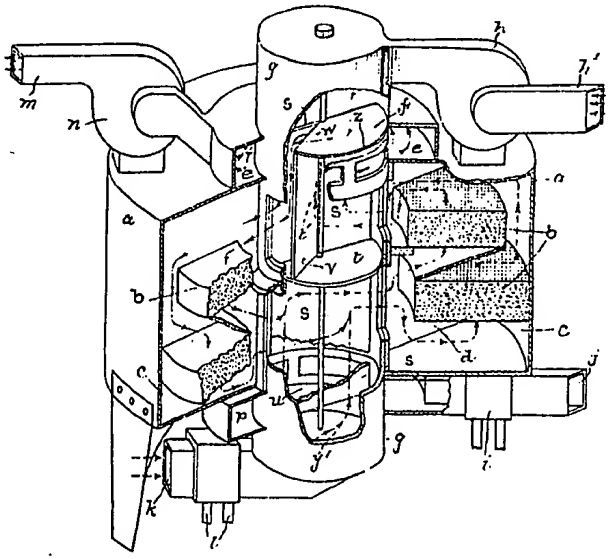


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Fig. 3

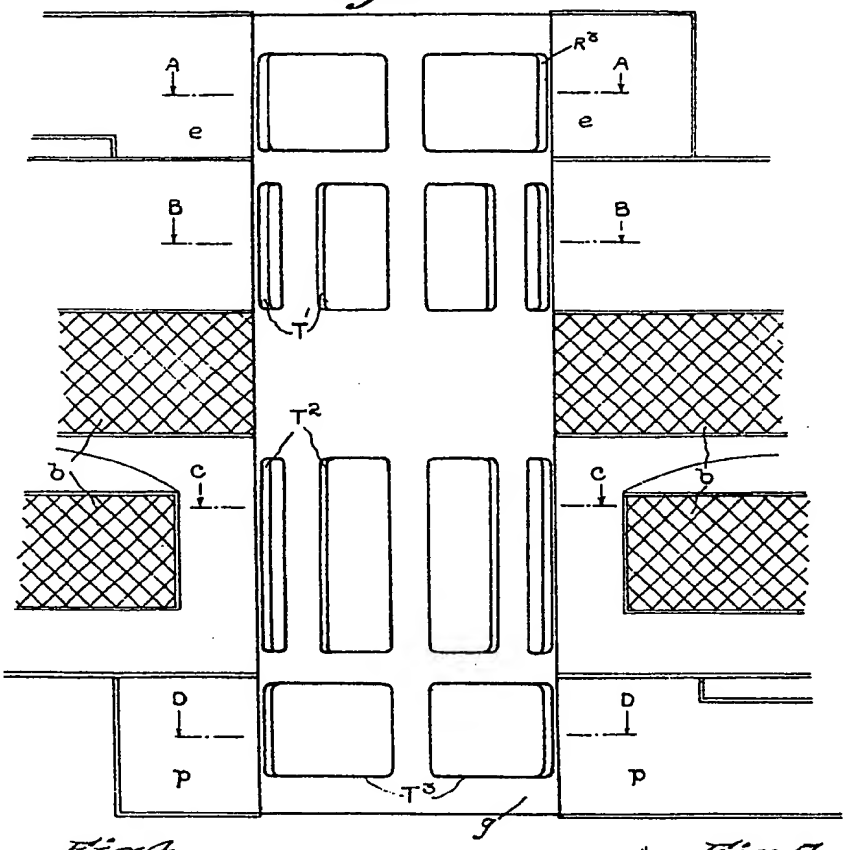


Fig. 4

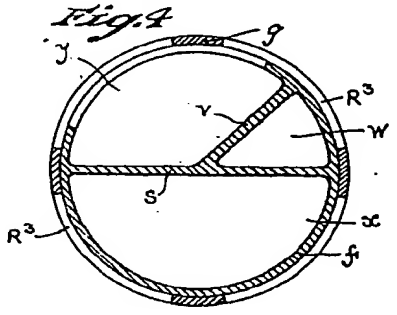


Fig. 5

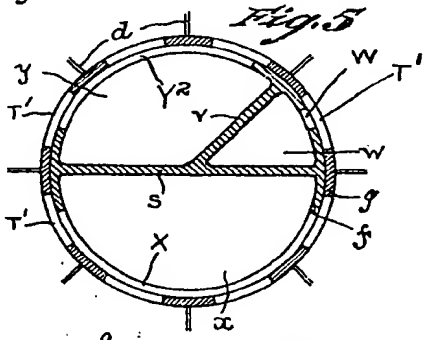


Fig. 6

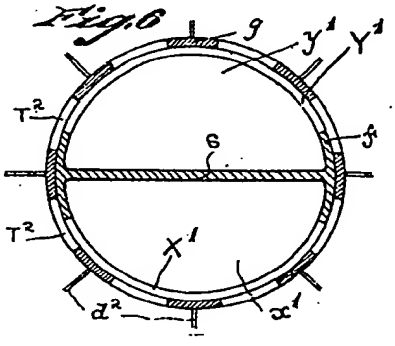


Fig. 7

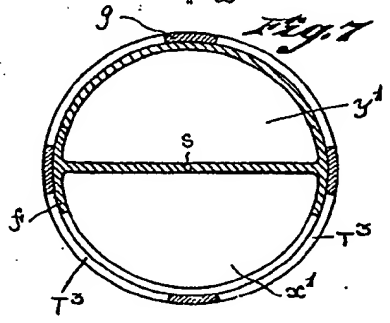


Fig. 8

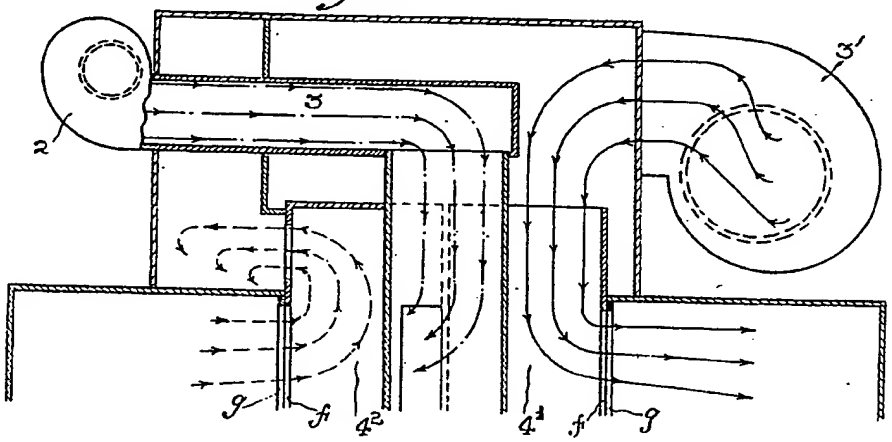
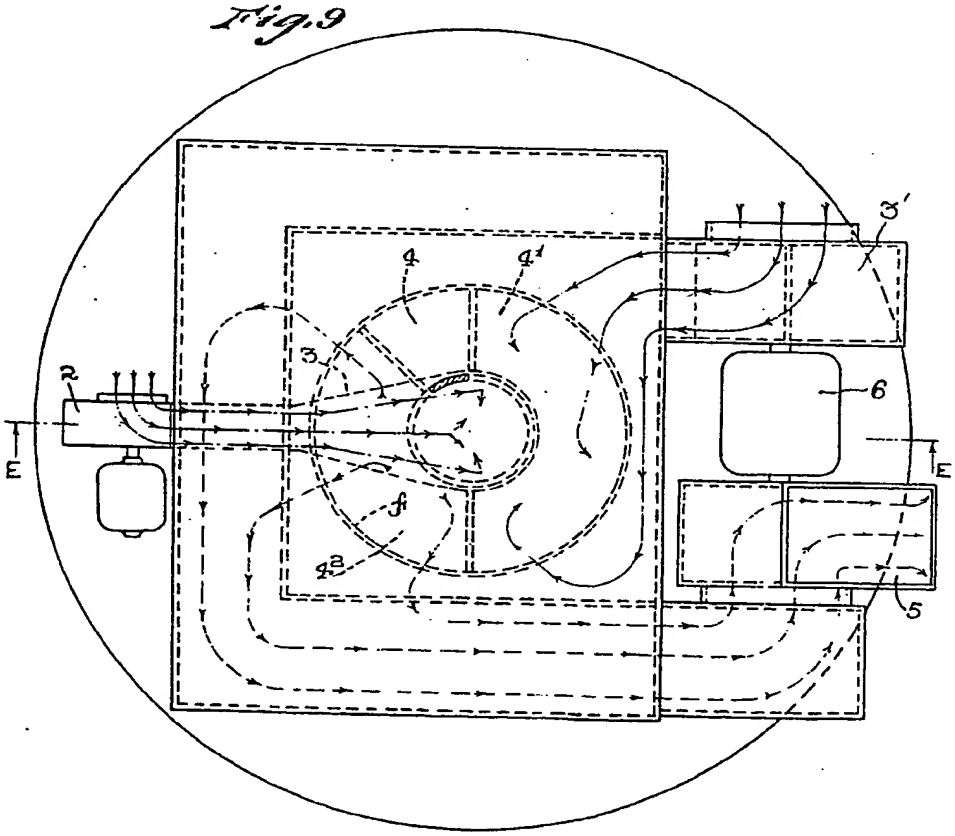


Fig. 9



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508,372 COMPLETE SPECIFICATION

7 SHEETS

SHEET 3

SHEET 4

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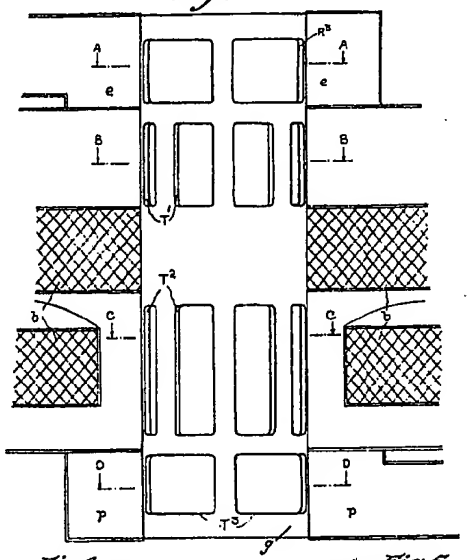
Fig. 3



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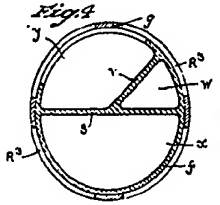
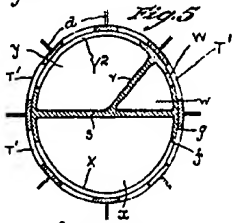


Fig. 5



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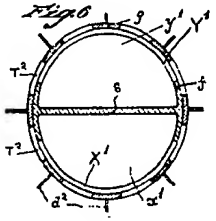
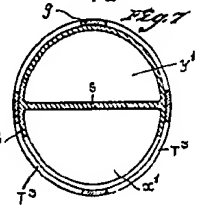


Fig. 7



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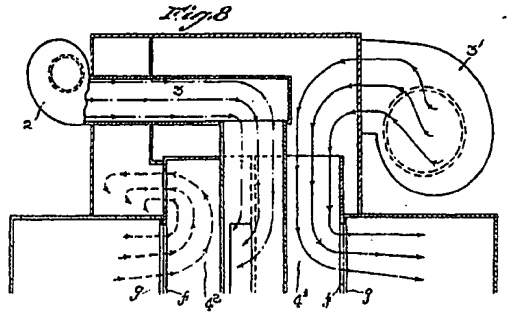

Fig. 9

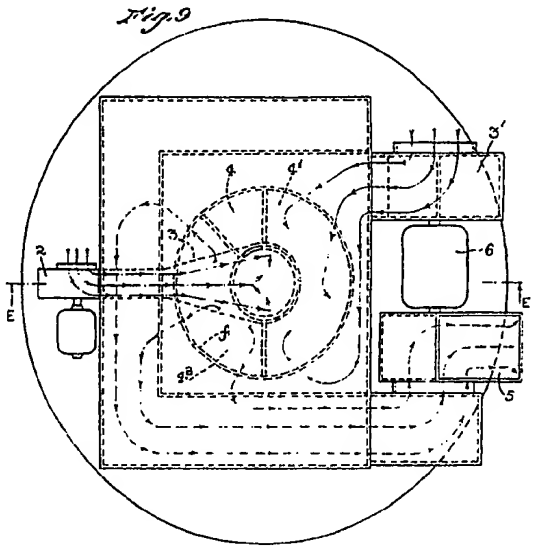

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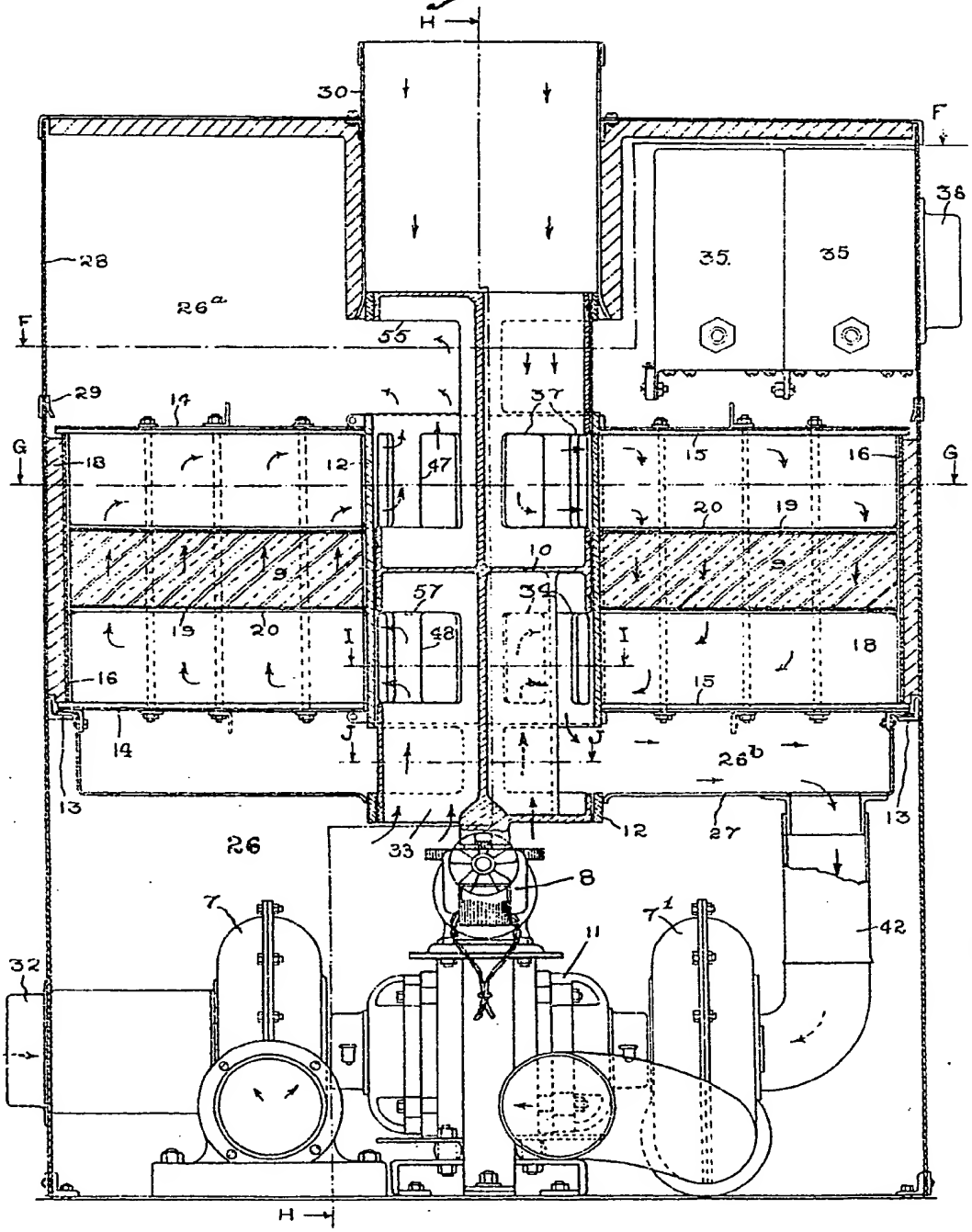
Fig. 10



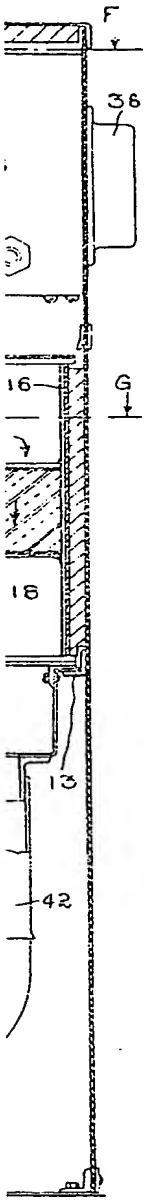


Fig. 13

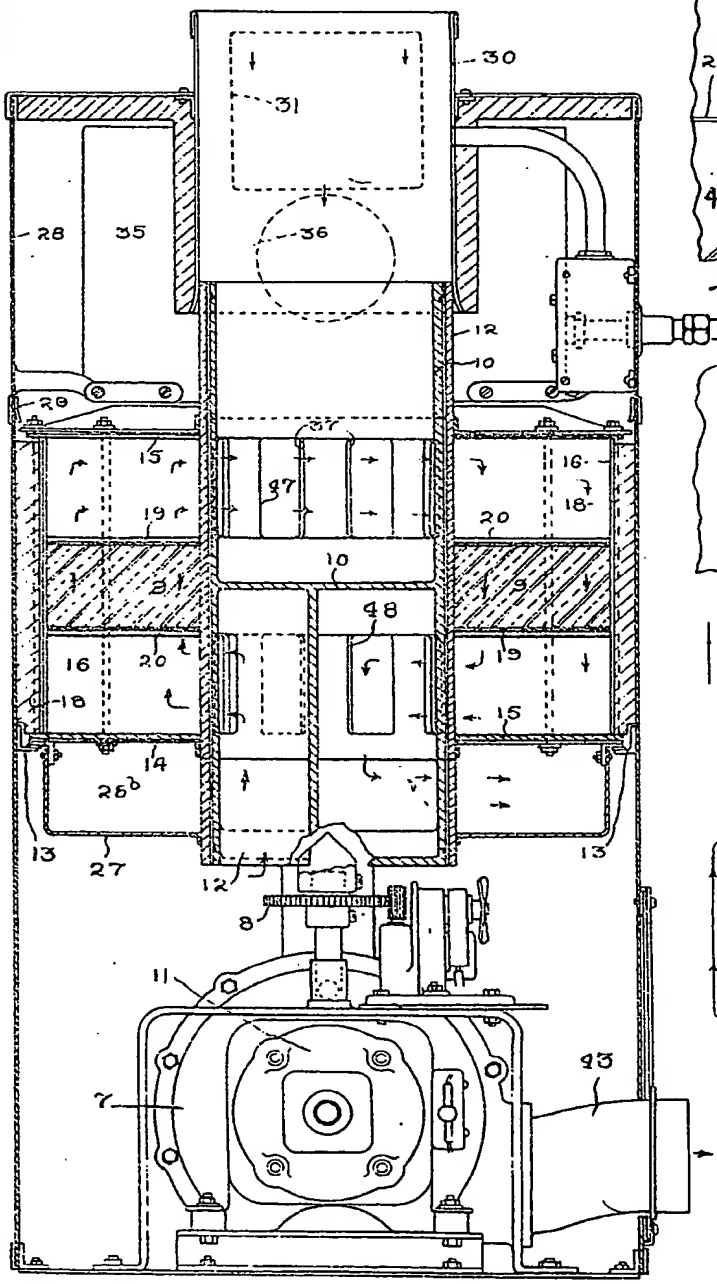


Fig. 14

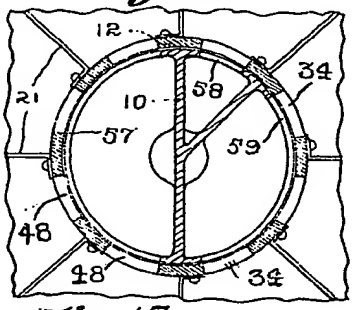


Fig. 15

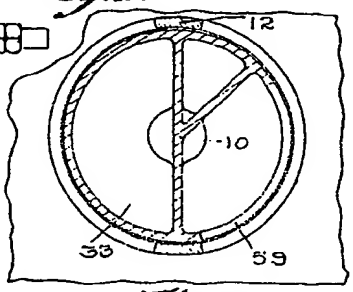
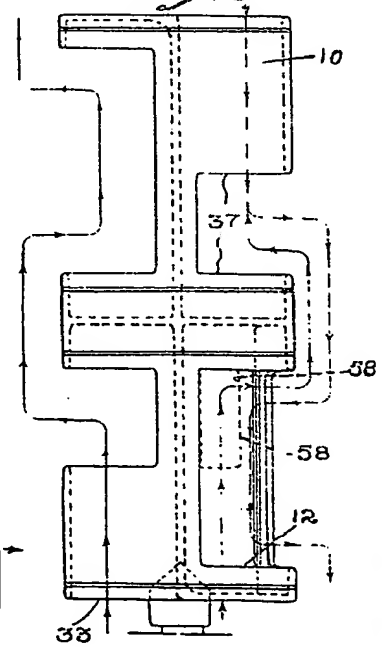


Fig. 16



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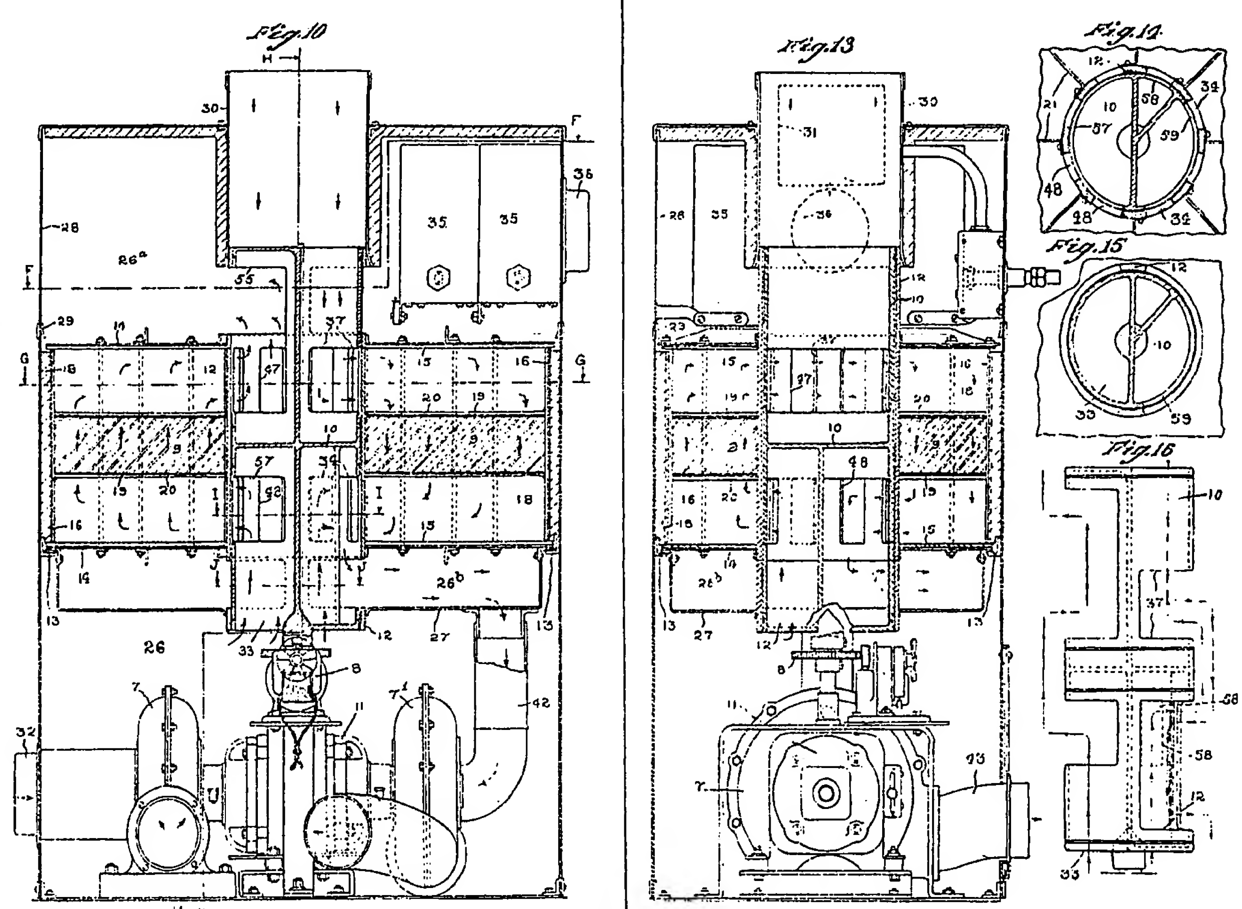

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Fig. 11

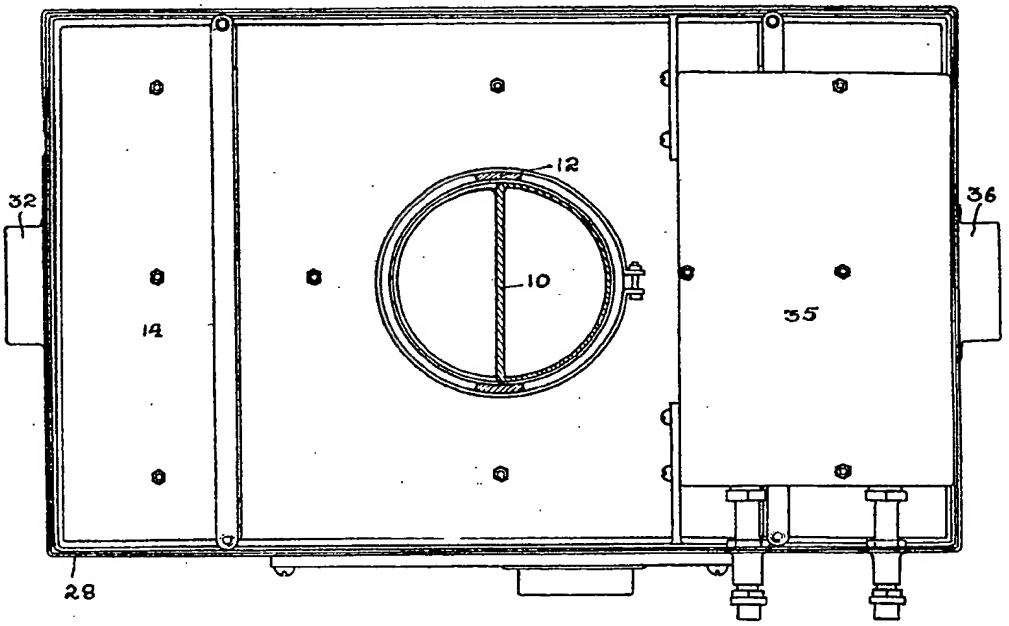
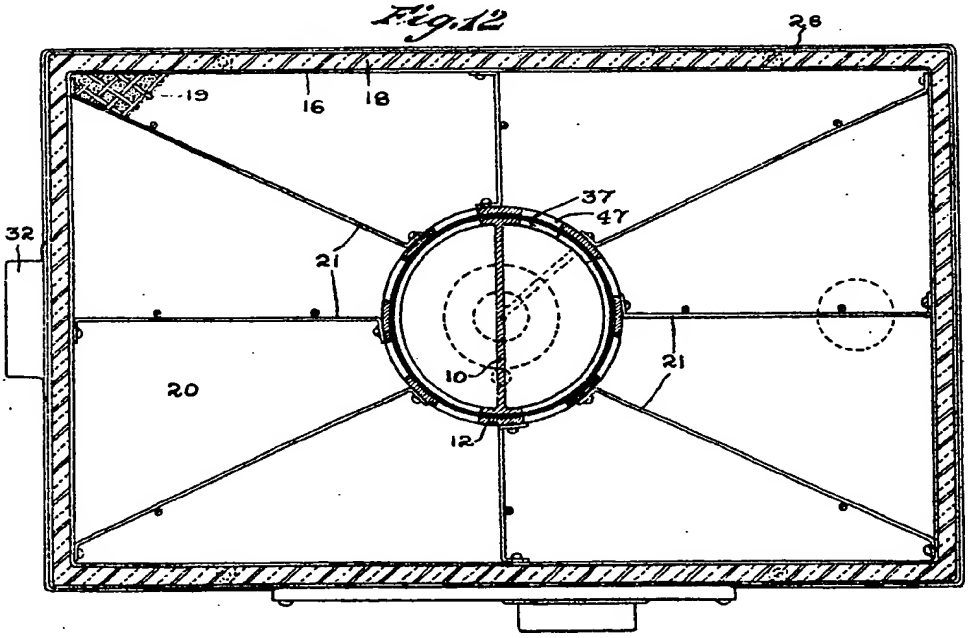


Fig. 12



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